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Portuguese artisanal octopus fisheries: analyzing local ecological knowledge and management perceptions

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ABSTRACT

The excessive fishing effort during several decades led to the collapse of many stocks, partly due to a mixture of lack of appropriate scientific information, deficient management systems, default of rules and regulations by fishers and incapacity to enforce them by authorities. Given the failure of the top-down centralist system dominated by the state, a demand for progressive decentralization of decision-making process emerged and calls for co-management systems, a new concept in fisheries management that considers the importance of the participation of social agents, have increased.

Cephalopods are one of the main exploited resources in the South of Europe. In Portugal, *Octopus vulgaris* is consistently one of the most important resource to artisanal fleet, estimated as the most important in value and fourth in terms of quantities landing (2016). Octopus is a singular species in terms of biological characteristics and environmental sensitivity, which make the management of this resource a real challenge. Cephalopods' management fall under national governments, and in Portugal measures are mainly related with minimum landing weight and gears. The present dissertation is organized in two main sections, each corresponding to a research article. This work had as practical methodology inquires conducted in several fishing ports of Portuguese coast (Cascais, Sesimbra, Sines, Ferragudo, Santa Luzia and Fuzeta). Questionnaires included different sections dedicated to fishing operation, knowledge about octopus' ecology, opinions about management measures and management plan and demographic characteristics. The first article compared local ecological knowledge of fishers with scientific knowledge obtained from literature regarding octopus' life cycle. The second article analysed fishers opinions and perceptions relative to management measures and plans for octopus fishery.

Fishing communities in Portuguese coast have shown a high dependence on this resource, and their answers revealed a medium knowledge about octopus' biological characteristics. Regarding fishers' opinions about management, different perceptions were found between regions. However, the implementation of biological closures and management plans developed by fishers were found consistently accepted management measures all over the country. In general, fishers were not satisfied with the actual management and this has reflections in their attitudes. The development of education and awareness actions in fishing communities focused on the biological characteristics of octopus and fishing impacts on the resource could promote a better understanding and respect for management measures. Having into consideration fishers' perceptions and opinions about management has the potential to facilitate successful planning and development of management measures which fishers will accept as legitimate. Fishers' participation could increase their receptivity to management. Also, the involvement of stakeholders in the development of management measures provides a sense of worth that may cultivate a greater responsibility of fishers about the resource.

KEYWORDS: Octopus, fishers, co-management, management measures, fisheries, Portugal

RESUMO

A pesca excessiva durante várias décadas conduziu ao colapso de vários *stocks* de recursos marinhos, quer devido à falta de informação científica apropriada, quer devido aos sistemas de gestão deficitários ou à falha da imposição das medidas aos pescadores. Considerando o fracasso do sistema centralizado e dominado pelo estado (*"top-down")*, surgiu a necessidade da descentralização do processo de tomada de decisão, apelando a sistemas de co-gestão, um novo conceito na gestão das pescas que considera a importância da importância das partes envolvidas.

Os cefalópodes são um dos recursos mais explorados no sul da Europa. Em Portugal, *Octopus vulgaris* é um dos recursos mais importantes para a frota artesanal do país, estimado como o primeiro em termos de valor e o quarto mais importante em termos de quantidade desembarcada (2016). O polvo é uma espécie singular em termos de características biológicas e sensibilidade a variações ambientais, tornando a sua gestão um verdadeiro desafio. A gestão dos cefalópodes está sob tutela do governo nacional e, em Portugal, as medidas de gestão impostas relacionam-se, sobretudo, com o peso mínimo de captura e com as armadilhas usadas (covos ou alcatruzes). A presente dissertação está organizada em duas secções, cada uma correspondente a um artigo científico. Este trabalho teve como metodologia a realização de inquéritos em vários portos de pesca da costa portuguesa (Cascais, Sesimbra, Sines, Ferragudo, Santa Luzia e Fuzeta). Os inquéritos foram desenvolvidos com diferentes secções sobre características de funcionamento da atividade, conhecimento acerca de aspetos da ecologia do polvo comum, opiniões acerca do plano e de medidas de gestão e características demográficas. No primeiro artigo efetuou-se uma análise comparativa entre o conhecimento empírico dos pescadores e o de natureza científica obtido na literatura acerca de aspetos relacionados com o ciclo de vida do polvo. O segundo artigo analisou dados recolhidos durante o desenvolvimento da presente dissertação e dados previamente recolhidos no âmbito de um projeto sobre o plano e medidas de gestão do polvo na costa portuguesa. Estes dados foram compilados de forma a transmitir uma análise com maior alcance e que considerasse várias comunidades piscatórias.

As comunidades piscatórias da costa portuguesa mostram uma dependência elevada deste recurso e revelaram um conhecimento aceitável do recurso que exploram. Foram identificadas diferentes perceções a algumas medidas de gestão entre as regiões, mas, de uma forma geral, duas medidas de gestão revelaram-se como significativamente aceites: implementação de defeso à pesca e desenvolvimento de um plano de gestão por pescadores. Ainda, de uma forma geral, os pescadores não se mostraram satisfeitos com a gestão atual do polvo, o que se revela nas suas atitudes perante limitações definidas por lei. O desenvolvimento de ações de sensibilização acerca das características biológicas do polvo e dos impactos da pesca pode promover uma maior compreensão e respeito pelas medidas de gestão. Da mesma forma, a sua participação poderá aumentar a recetividade do setor à gestão. Ainda, o envolvimento dos pescadores no desenvolvimento das medidas de gestão pode provocar uma maior responsabilidade dos pescadores sob o recurso.

PALAVRAS-CHAVE: Polvo, pescadores, medidas de gestão, pesca, Portugal

RESUMO ALARGADO

A pesca excessiva durante várias décadas conduziu ao colapso de vários *stocks* de recursos marinhos, quer devido à falta de informação científica apropriada, quer devido aos sistemas de gestão deficitários ou à falha da imposição das medidas aos pescadores. A gestão das pescas tem sido, historicamente, desenvolvida com base em dados e aconselhamento científico, contudo, dado o fracasso do sistema de gestão centralizado e dominado pelo Estado, surge a necessidade da descentralização do processo da tomada de decisões relativas à gestão das pescas. Nas últimas décadas, surgiu um novo conceito que destaca a importância da participação das partes envolvidas na pesca: um sistema de co-gestão, ou gestão partilhada. Este conceito foi definido em 1991 como "a partilha de poder e responsabilidade entre o governo e os utilizadores dos recursos locais" (Berkes et al, 1991).

É fundamental considerar que o sucesso de um plano de gestão pode ser definido de acordo com objetivos biológicos, económicos, sociais e políticos. No caso de um desses objetivos falhar, os outros não poderão ser atingidos. Assim sendo, é necessário que seja desenvolvido um plano de gestão conjunto pelas comunidades piscatórias e pelas autoridades de gestão.

Os pescadores detêm um conhecimento profundo acerca da distribuição e do comportamento dos recursos a nível local. Esse conhecimento local (do inglês *Local Ecological Knowledge, LEK*), deve ser visto como uma fonte primária de informação, que não deve ser ignorada. Esse conhecimento é de difícil acesso e desafiante de trabalhar. No entanto, é essencial que os cientistas expandam as suas fontes de dados e que incorporem novas informações. Deve ser feito um trabalho próximo entre pescadores e gestores, de forma a que sejam desenvolvidas medidas de gestão novas e fiáveis. A combinação do conhecimento científico com o conhecimento local permitirá o desenvolvimento de planos de gestão mais robustos, pela colmatação de falhas existentes. Além disso, vários autores sugerem que os pescadores serão mais recetivos aos planos de gestão quando a sua experiência é tida em conta. Contudo, o conhecimento local continua ausente do desenvolvimento das medidas de gestão.

No Sul da Europa, entre os recursos mais explorados estão os cefalópodes. Portugal é um dos quatro principais contribuintes para os desembarques elevados, e o polvo comum (*Octopus vulgaris*) surge como um dos recursos mais importantes para a frota artesanal do país, estimado como o primeiro em termos de valor e o quarto mais importante em termos de quantidade desembarcada (2016). Esta espécie tem um ciclo de vida singular, sendo este de curta duração (12-14 meses) e com desova terminal da fêmea, cujos picos e épocas de desova descritas são variáveis consoante a zona de estudo. Este fator, entre outros, revela a suscetibilidade da espécie a variações ambientais, tornando a sua gestão um verdadeiro desafio.

A gestão dos cefalópodes não está sob a tutela da União Europeia e por isso encontra-se à responsabilidade do governo nacional. Em Portugal, trata-se de um sistema de gestão descendente (conhecido como "*top-down*") com muito pouca participação do setor piscatório na tomada de decisões. Atualmente, as medidas de gestão impostas relacionam-se, sobretudo, com o peso mínimo de captura e com as armadilhas usadas (covos ou alcatruzes). Historicamente, este recurso tem sido explorado sobretudo pela frota algarvia, mas nos dias de hoje, ganhou expressão em comunidades piscatórias artesanais em toda a costa portuguesa. Este facto deve-se, em parte, ao esgotamento de vários *stocks* de peixe, o que fez com que grande parte da frota alterasse a sua prática e adotasse como alvo o polvo, traduzindo-se num aumento de 50% nos últimos 20 anos, e que vem reforçar a necessidade emergente de se analisar a exploração deste recurso com mais precaução.

A presente dissertação está estruturada em duas secções principais, cada uma correspondente a um artigo científico, que serão submetidos para publicação em revistas internacionais. Este trabalho teve como metodologia a realização de inquéritos em vários portos de pesca da costa portuguesa (Cascais, Sesimbra, Sines, Ferragudo, Santa Luzia e Fuzeta). Os inquéritos foram desenvolvidos com diferentes secções nas quais se abordaram questões distintas: características de funcionamento da atividade,

conhecimento acerca de aspetos da ecologia do polvo comum, opiniões acerca do plano e de medidas de gestão e características demográficas.

No primeiro artigo efetuou-se uma análise comparativa entre o conhecimento empírico dos pescadores e o de natureza científica obtido na literatura acerca de aspetos relacionados com o ciclo de vida do polvo. Em muitos casos houve coincidência na informação destas fontes distintas, revelando que a generalidade dos pescadores possui um conhecimento aceitável acerca do recurso que explora. As questões nas quais foi encontrada maior variabilidade de respostas dadas pelos pescadores coincidem com aspetos para os quais as evidências científicas também apresentam maior variabilidade. A importância de que os pescadores conheçam os aspetos biológicos do recurso prende-se com a necessidade de compreender e respeitar as medidas de gestão. Além disso, o desenvolvimento de ações de sensibilização e a transferência de conhecimentos, tanto das características biológicas como dos impactos da pesca, podem promover pescadores mais conscientes, sobretudo devido à preocupação que o setor tem em otimizar as capturas e minimizar o esforço. O desenvolvimento de mais estudos científicos para recolha de dados é também essencial para aumentar o conhecimento do recurso, bem como desenvolver o intercâmbio do mesmo entre cientistas e pescadores.

O segundo artigo analisou dados recolhidos durante o desenvolvimento da presente dissertação e dados previamente recolhidos no âmbito de um projeto sobre o plano e medidas de gestão do polvo na costa portuguesa. Estes dados foram compilados de forma a transmitir uma análise com maior alcance e que considerasse várias comunidades piscatórias. Foram estabelecidas três regiões de análise (noroeste, sudoeste e sul), de forma a possibilitar a comparação de opiniões que têm como base as questões relativas às medidas e ao plano de gestão. Os pescadores foram ainda questionados acerca do seu interesse em estar, ou não, envolvidos num plano de gestão e quais os motivos para esse interesse. Além disso, foi-lhes pedido que identificassem os motivos para a falha das medidas de gestão. Esta análise comparativa, permitiu encontrar características demográficas semelhantes entre as comunidades piscatórias consideradas. Foram identificadas diferentes perceções a algumas medidas de gestão entre as regiões, mas, de uma forma geral, duas medidas de gestão revelaram-se como significativamente aceites: implementação de defeso à pesca e desenvolvimento de um plano de gestão por pescadores. Ainda, de uma forma geral, os pescadores não se mostraram satisfeitos com a gestão atual do polvo, o que se revela nas suas atitudes perante limitações definidas por lei (como ultrapassar o número máximo permitido de armadilhas, assumido pelos próprios pescadores). Conforme sugerido por diversos autores, os pescadores têm mais tendência para não se sentirem satisfeitos com a gestão quando a sua experiência não é considerada e quando são excluídos do processo de tomada de decisões. Da mesma forma, a sua participação poderá aumentar a recetividade do setor à gestão. A compreensão das opiniões e perceções dos pescadores pode ser extremamente útil no desenvolvimento do planeamento e aplicação das medidas de gestão.

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1. GENERAL INTRODUCTION

During 1950s and 1960s, an intensification in the global fishing effort occurred, that led to an increase in catches. This period created the basis for worldwide fisheries industrialization. The trend of this raise in catches generated an impression to managers and politicians that more boats lead to higher catches, and fishers behaved like other sectors of economy, believing that increased inputs lead to increased outputs (Pauly et al. 2002; Pauly 2009). In fact, a slow decline in reported world fisheries started to be noticed since late 1980s, by about 0.7 million tonnes per year (Pauly et al. 2002). The excessive fishing effort generated the collapse of many stocks, either due to a lack of appropriate scientific information and/or deficient management systems and/or failure to enforce rules and regulations (Freire & García-Allut 2000). Despite some progress in the improvement of the state of the world's marine fish stocks in recent years, stocks have not improved overall. Based on FAO' analysis of assessed commercial fish stocks, 90 percent of fish stocks were at biologically sustainable levels in 1974, this value decreased to 68.6 percent in 2013. Thus, 31.4 percent of fish stocks were estimated as overfished (FAO 2016). Some reductions in exploitation rates were achieved through management actions, however, if there are not further reductions in catches, a significant fraction of stocks will remain collapsed (Worm et al. 2009).

According to Jentoft (2000), overfishing may occur when moderation, prudence and community solidarity is destroyed. This arise when fishers have a lack of concern about the resource, the community and each other. If fish resource disappeared, fishing communities would decay, fishers would have to find alternative employment and, consequently, they would no longer be fishing communities (Jentoft 2000). It is also important to consider that the success of a management system can be defined in terms of biological, economic, social and political objectives. In the case of a depleted stock, economic and social objectives cannot be achieved. Similarly, biological objectives cannot be achieved if economic and social objectives aren't considered. Thus, a management plan should come from the combination of fishing communities and management authority (Beddington et al. 2007).

Given the failure of the top-down centralist system dominated by the state, the need for a progressive decentralization of the decision-making process emerged. A new concept in fisheries management that regards the importance of social agents' participation should be contemplated in the political process. A co-management system should guarantee fisher's confidence in the political system resulting in measures being better applied (Suárez de Vivero et al. 2008). As defended by Jentoft "Viable fisheries communities require viable fish stocks" and the opposite also applies. Therefore, it was suggested that fisheries management systems adopt designs that fortify cooperation among local communities, instead of promoting opportunistic and profit-seeking individuals. Fisheries management system should contemplate communities in order not to fail (Jentoft 2000).

However, overfishing is not the only problem affecting fishing communities. There are worldwide problems, about illegal, unreported and unregulated (IUU) fishing, that affects all types of fishing vessels (Gallic & Cox 2006). Illicit fishing may account for up to 26 million tonnes of fish per year, or more than 15 percent of the world's total annual capture fisheries output. These practices provoke economic problems and threaten biodiversity and food security. A weak legal framework and lack of political will have been the major impediments to deal with IUU. To tackle IUU fishing, it is necessary to monitor and control fishing activities, but also to develop global guidelines or measures for market access, trade and traceability mechanisms, otherwise IUU will continue to be an obstacle to achieve sustainable fisheries (FAO 2016). Nonetheless, a case study had estimated reductions in illegal fishing in 10 areas out of 15 areas since the early 1990s and reported a correlation between governance and the level of illegal fishing, revealing a higher risk of illegal fishing in developing countries (Agnew et al. 2009).

Throughout the world, another major concern is post-harvest fish losses. Between landing and

consumption, 27 percent of landed fish is lost or wasted. If discards prior to landings are considered, fish losses and waste account 35 percent of landings, of which at least 8 percent is perfectly edible fish being thrown back into the ocean (FAO 2016). The impacts of discards are no easily quantifiable and the methods for impact assessment need more development (Kelleher, 2005). Usually it can be seen as a symptom of over-exploitation and market choices (Borges 2015). Some tools were suggested to reduce discards: control of fishing capacity and effort, improve of fishing gears (to increase selectivity), spatial and temporal closures and legal limits. The success of all these measures dependent of fishers' acceptance of the measure and behaviour, reinforcing the importance of involving the fishing sector in the decision-making process of designing management measures, and the active management of their activity. To be effective, measures should be practical, effective, compatible with other measures and integrated on fisheries management systems (FAO 2016). If not properly controlled, discards can compromise the effectiveness of management system measures (Borges 2015).

From a general perspective, and as pointed out by FAO, there is a need to coordinate different activities taking place in water space and deal with the increasing use of resources, identifying the cumulative impacts and integrating sustainability goals and legal frameworks. It is crucial to reinforce aquatic ecosystem governance to ensure that sustainability goals and environmental protection are aligned with social and economic development goals (FAO 2016). In fact, a major goal for future management regimes is to avoid the extinction of species that before were protected by their inaccessibility to fishing gear. Basically, there are two alternatives for fisheries management: continuing as usual or convert fisheries management into a more balanced management that require consideration of more stakeholders (Pauly 2009). Considering that throughout the world the number of fisheries collapsed increased and catches continue to decline, a huge reduction of fishing effort (involving decommissioning) and fisheries regulation contemplating a precautionary principle must be implemented, as well as the increase of political will (Pauly et al. 2002). Given the high level of uncertainty facing the management of fisheries, different measures had been suggested. Closing a part of the fishing grounds was interpreted as a measure that can put fisheries on an ecologically sustainable path and prevent overexploitation by setting an upper limit on fishing mortality (Pauly et al. 2002; Pauly 2009).

Despite all the projections made by FAO up to 2025 with regards to fish production, prices, consumption and trade, among other factors, can affect them. The next decade will probably be characterized by major changes in the environment, resources, economic conditions, market characteristics and social conduct, which may strongly influence fishing sector in the medium term (FAO 2016).

All the driving forces of fisheries (market-based economic reforms, technological innovations, decentralization and participation, human population growth, among others) have the potential to strongly impact on the fishing sector in the near future, although the direction of the impacts (for better or worse) is still largely unknown. Considering that well managed and devastated fisheries coexist in the same region and the homogenizing effects of globalization, the future of the fishery sector could be defined as a collage of different situations. There is not a conclusive scenario, but certainly the future of marine capture fisheries will be conditioned by the political, social and economic evolution of the world (Garcia & Grainger 2005).

The present work focused the Portuguese octopus artisanal fisheries and compared fisher's local ecological knowledge with scientific data in order to evaluate the usefulness of incorporating LEK in fisheries management. It also analysed through data collected through questionnaires in several fishers communities fishers' perpectives relative to octopus fishery management.

1.1. REFERENCES

Agnew, D. J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J. R., and Pitcher, T. J. 2009. Estimating the worldwide extent of illegal fishing. PLoS ONE, 4.

Beddington, J. R., Agnew, D. J., and Clark, C. W. 2007. Current problems in the management of marine fisheries. Science (New York, N.Y.), 316: 1713–1716.

Borges, L. 2015. The evolution of a discard policy in Europe. Fish and Fisheries, 16: 534–540.

FAO. 2016. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome.200 pp. Rome. 223 pp.

Freire, J., and García-Allut, A. 2000. Socieconomic and biological causes of management failures in european artisanal fisheries: Marine Policy, 24: 375–384.

Gallic, B. Le, and Cox, A. 2006. An economic analysis of illegal, unreported and unregulated (IUU) fishing: Key drivers and possible solutions. Marine Policy, 30: 689–695.

Garcia, S. M., and Grainger, R. J. R. 2005. Gloom and doom? The future of marine capture fisheries. Philosophical Transactions of the Royal Society B: Biological Sciences, 360: 21–46.

Jentoft, S. 2000. The community: a missing link of fisheries management. Marine Policy, 24: 53–60.

Pauly, D., Christensen, V., Guénette, S., Pitcher, T. J., Sumaila, U. R., Walters, C. J., Watson, R., *et al.* 2002. Towards sustainability in world fisheries. Nature, 418: 689–695.

Pauly, D. 2009. Beyond duplicity and ignorance in global fisheries. Scientia Marina, 73: 215–224.

Suárez de Vivero, J. L., Rodríguez Mateos, J. C., and Florido del Corral, D. 2008. The paradox of public participation in fisheries governance. The rising number of actors and the devolution process. Marine Policy, 32: 319–325.

Worm, B., Hilborn, R., Baum, J. K., Branch, T. A., Collie, J. S., Costello, C., Fogarty, M. J., *et al.* 2009. Rebuilding Global Fisheries. Science, 325: 578–585.

2. PORTUGUESE OCTOPUS ARTISANAL FISHERIES: COMPARISON BETWEEN LOCAL ECOLOGICAL KNOWLEDGE AND SCIENTIFIC DATA

ABSTRACT

Scientific based management aims at a large scale while resource users, like fishers, hold detailed understanding about the distribution and behaviour of resources at the local level. Moreover, fishers could be more receptive to management measures if their experience is considered. Despite fishers' knowledge is difficult to access and challenging for scientists to deal with, it could provide more robust and reliable assessments. *Octopus vulgaris* in one of the most important fishing resources to Portugal. It is a singular species in terms of biological characteristics and environmental sensitivity, which make the management of this resource a real challenge. Questionnaires were developed in several fishing ports to collected fishers' perception about octopus' life cycle. A review of the literature was conducted to collect scientific evidences in order to compare scientific data and fisher's knowledge. Frequency of occurrences were estimated for the sections about biological knowledge to discriminate obtained answers and to analyse which answer predominated in fisher's communities. There was some overlap between fishers' LEK and scientific findings, revealing that fishers have a moderate knowledge about the resource. Characteristics in which fishers reveal some heterogeneous opinions coincided with the biological features where science also revealed less robust knowledge. It is crucial that fishers are aware about the biological characteristics of such a singular resource to understand and respect management measures that could protect this species. Furthermore, developing of awareness will promote more conscious fishers.

KEYWORDS: *Octopus, Local Ecological Knowledge, artisanal fisheries, management, fishers*

2.1. INTRODUCTION

Despite some progress, the state of world's marine fish stock has not improved overall. In 1974, the share of fish stocks within biologically sustainable levels was 90 percent and in 2013 this value had dropped to 68.6 percent, with 31.4 percent of fish stocks estimated as overfished (FAO 2016).

Global marine capture fishery production, in 2014, was 81.5 million tonnes. Four highly valuable groups (tunas, lobsters, shrimps and cephalopods) registered new record catches in 2014. Since 2008, world catches of octopuses have remained relatively stable at about 350 000 tonnes (t) (FAO 2016). In Europe, total cephalopod landings from the Northeast Atlantic and Mediterranean (including landings by non-European countries) have increased from 30 000 t annually, in 1950, to 120 000 t, in 2010, and to 656 000 t, in 2014 (European Comission, 2017). The common octopus (*O. vulgaris*) dominates the catches and landings in weight and number in the southern part of Europe and Portugal is one of four countries that have been responsible for the majority of landings (Pierce et al. 2010).

Cephalopod fisheries in the European Union (EU) are excluded from quota regulations under the Common Fisheries Policy (CFP) and management fall under national and/or local jurisdiction. In Portugal, fisheries management is carried out by a top-down system based on input and output control measures and the participation of fishers in the process, although increasing, is still scarce (Pita et al. 2015). Technical measures for the management of octopus are provided by the national fisheries research institute, local governmental counterparts and higher education research institutions. Since 2010 fishers have been called to provide advice about octopus fisheries, however their formal participation in the decision-making process is still limited (Pita et al. 2015; Sonderblohm et al. 2017).

Scientific based management aims at a large scale while resource users (like fishers) hold detailed in depth understanding about the distribution and behaviour of resources at the local level. Such rich

information should not be ignored. However, local ecological knowledge (LEK), remains absent from the development of management plans and from stock assessment (Neis et al. 1999). Decision-making bodies would benefit from working closely with resource users, in order to develop new and reliable management measures (Pita et al. 2010).

Combining hard scientific data and local ecological knowledge (LEK) reduces uncertainty and provides more robust and reliable assessments. Furthermore, fishers will be more receptive to local management and conservation efforts when their experience is considered (Mackinson & Nottestad 1998; Neis et al. 1999; Bender et al. 2014; Pita et al. 2015). This will contribute to co-management, a concept defined as 'the sharing of power and responsibility between the government and local resource users (Berkes et al. 1991).

Fishers' LEK, a rich primary source of information (Mackinson & Nottestad 1998), is difficult to access and is in a different format of scientific information which is challenging for scientists to deal with. However, it's important that fisheries scientists expand data source, looking to incorporate new and different data instead of searching solely for ways to work with old data. Despite the fact fishers' knowledge can be biased, the perceptions of fishers about resource abundance and impacts is mostly acquired to optimise catches and minimising effort (Neis et al. 1999).

Several studies have been developed to integrate LEK in fisheries management. In the tropics, several studies examined the integration of LEK to use this information as indicators for fisheries management. As a result, authors found that the negotiation of shared understandings between multiple sources of knowledge must be a continuous process within an adaptive framework (Wilson et al. 2006). In Southwestern Atlantic, several authors developed a study where they have demonstrated the decline of reef fisheries from multiple sources of information. Authors emphasize the importance of combining LEK to improve our understanding of marine habitat's status and its associated biodiversity (Bender et al. 2014). In Galicia, LEK was tested to map the distribution of fishing grounds. Geographical positioning systems data-loggers and fishing log-books were used to monitor the activity of vessels and estimates the distribution of the fishing intensity and Catch Per Unit Effort (CPUE). Authors concluded that fisher's LEK can complement scientific knowledge and be used as a powerful tool for fisheries management, especially in data poor situations (Pita et al. 2016).

The common octopus (*Octopus vulgaris*) is a benthic species that inhabits the coastline to the inner edge of the continental shelf (200 m depth) and undertakes limited seasonal migrations (Pierce et al. 2010). This species have a life cycle of 12-14 months and terminal spawning with egg care by the female (Domain et al. 2000). The common octopus is characterized, as other cephalopods, as opportunistic predators. Diet of juvenile and adults include crustaceans, fish, and bivalves (Rosa et al. 2004).

Different reproduction frequency and seasons were identified by different authors (Silva et al. 2002; Otero et al. 2007; Pierce et al. 2010; Lourenço et al. 2012) and influence and importance of environmental factors on the reproduction cycle, interfering in timing, intensity and synchronism have also been demonstrated (Sobrino et al. 2002). Consequently, it was suggested that populations exposed to fisheries in different geographic areas must be managed at the local level (Lourenço et al. 2012).

Common octopus juveniles are widely and patchy distributed along the Portuguese coast, at mean depths of 80m, at 10-15km from the coastline principally in areas near estuarine and lagune systems (Moreno et al. 2014). Most of the population occupied habitats with different substrates (rocks, gravels, sand) (Silva et al. 2002) however a positive relationship between small size octopus density and sediment grain size was suggested (Moreno et al. 2014).

Considering that the recruitment is affected by external factors, environmental variability may cause a drastic decrease in the population and, consequently, a decrease of landings (Sobrino et al. 2002). Although this resource have a continuous fishing pressure, the populations of ICES (International Council for the Explorations of the Sea) areas (areas in the Northeast Atlantic managed byICES) remain stable in trend catches, with some fluctuations (ICES 2014).

Portuguese small-scale fishers have been targeting the common octopus for a long time. Nowadays quantities landed and commercial value of this species makes it an increasingly important fishery resource, that demands an appropriate stock assessment and management measure to safeguard its future (Pita et al. 2015). The present work compared fisher's Local Ecological Knowledge with scientific data in order to evaluate the potential use of fisher's LEK in developing the knowledge base for octopus' fisheries management.

2.2. METHODS

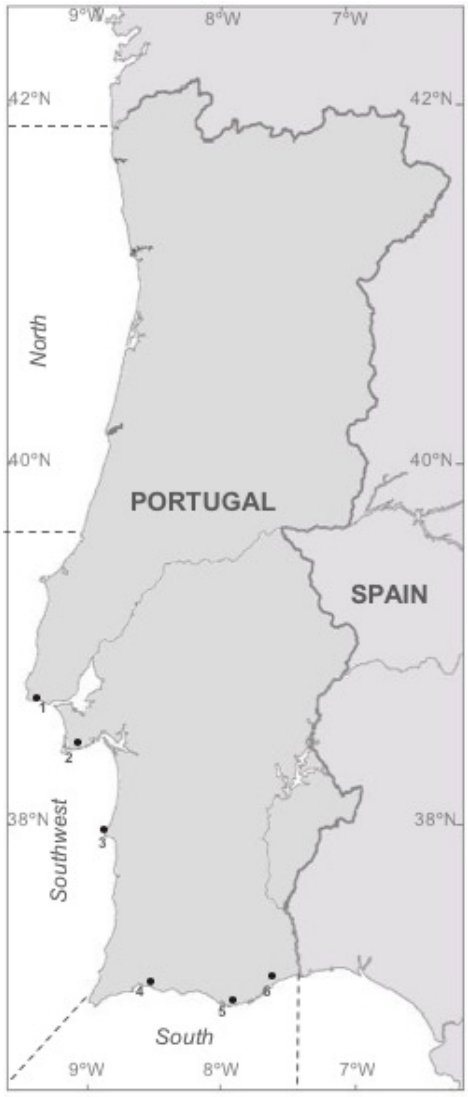

Figure 2.1 – Map of mainland Portugal fishing ports were interviews took place (1-Cascais, 2-Sesimbra, 3-Sines, 4-Ferragudo, 5-Fuzeta, 6-Santa Luzia)

A questionnaire survey was conducted in 6 fishing ports (Cascais, Ferragudo, Fuzeta, Santa Luzia, Sesimbra and Sines) (Figure 2.1), with fishers who spend most of the year targeting the common octopus. Due to the fact that the south region of Portugal has been historically dependent on the common octopus fishery (Pilar-Fonseca et al. 2014), ports were organized in two regions: South (Ferragudo, Fuzeta, Santa Luzia) and Southwest coast (Cascais, Sesimbra, Sines) to compare fishers' knowledge about octopus.

Considering the recent number of known fishing licenses by fishing ports, the sample size was calculated as statistically significant to allow for ± 5% error of estimates. However, the number of licenses does not correspond to the real number of boats targeting the common octopus, and so the real number was considered as the number indicated by fishers. The total number of interviews represented between 75 to 80% of the total number of boats suggested by fishers.

Questionnaires (Annex A) were developed with different sections aiming to collect information about the fishery, biological knowledge about octopus and demographic characteristics. In the section about the fishery, questions asked were role on board, type of fleet (local or coastal), type of gear used (pots or traps). In the section about biological knowledge, fishers were asked about the type of reproduction, times of reproduction per year, reproduction seasons, paralarvae/juvenile areas, longevity, abundance of octopus (more or less comparing with the past), feeding and habitat. In the demographic section, questions asked were age of the fisher, years of experience, how many generations were related with fisheries, economic dependence of fisheries, education level and residence area. Most questions were close-end except for biological questions that were open-end questions to avoid bias due to suggested answers. Any relevant comments mentioned by fishers during the interviews were also registered. Fishers were approached randomly in the harbour and one interview was carried out by boat. The survey was carried out through face to face interviews and took place from October 2016 to July 2017, resulting in a total of 91 interviews.

Descriptive statistics were used to describe demographic characteristics for each fishing port in order to characterized fisher's communities. A review of the literature was conducted to collect scientific evidence about octopus's biological characteristics in order to compare scientific data and fisher's

knowledge. Frequency of occurrences were estimated for the sections about biological knowledge to discriminate obtained answers and to analyse which answer predominated in fisher's communities.

2.3. RESULTS AND DISCUSSION

2.3.1. Fisher's communities' characteristics

Fishing communities considered in the present study were organized in two groups to compare demographic characteristics and biological knowledge about octopus in two different sections of Portuguese' coast: ports in the southwest coast (Cascais, Sesimbra and Sines) and in the south coast (Ferragudo, Fuzeta and Santa Luzia) (Table 2.1).

Table 2.1– Demographic and fishing operation characteristics of fishers in the study sites. Data is shown as means (± standard deviation) and percentages

Variables	SouthWest Coast (n=43)	South Coast (n=48)
Demographic characteristics		
age (mean ± sd) (years)	52 ± 11	48 ± 12
experience fishing (mean± sd) (years)	34 ± 16	30 ± 14
years of schooling (mean± sd)	6 ± 1	6 ± 1
Family traditional in fisheries (number of generations related with fisheries) (mean± sd)	3 ± 1	3 ± 1
Fishing operation		
boat size (mean ± sd) (m)	8.5 ± 2.8	8.9 ± 2.1
type of gear used		
traps	91%	71%
pots	5%	19%
both	5%	10%
role on board		
skyper	67%	69%
other	33%	31%

The average age of fishers in both regions was over 45 years, and they had a long experience of fishing, reveling an ageing working force. Fishers had a low level of formal education. Fishers were heavily dependent on the fishing activity. Most fishers reported to have a family tradition in fisheries, while only a small portion reported to be first generation in the fishing sector. All fishers interviewed operated from artisanal boats, mostly in the local fleet (less than 9m length) and coastal fleet (more than 9m length), using mostly traps, interestingly more fishers reported to use pots in the south and in the southwest coast. Regarding their role on board, most interviewed fishers were skippers and the remaining were retired or part of the crew.

Small scale fisheries (SSF) have some common aspects, however, in Europe, SSF have a strong heterogeneity. It is frequent the use of different types of gear but polyvalence is not standardized within the sector. The variability is also present in other aspects as the degree of dependence on species or involvement in the activity. This may be full-time or part-time, in the case of combining the activity with other sources of income (Guyader et al. 2013). As revealed by the results of the present study, fishers interviewed in fishing communities depend exclusively on the common octopus, using two types

of passive gears (pots and traps). A high percentage of fishers have a full-time involvement, revealing a big dependence on the resource. These results are consistent with previous studies, that outlined that the artisanal fishing sector is very important for many Portuguese coastal communities. These communities are also characterized by middle-age fishers with low level of education (Pita 2014). In 1950, there were 39710 fishers in Portugal, representing 1.3% of total employed population. In 2011, the number of fishers decreased to 10802, representing 0.3% of total employed population. Regarding the mean age of fishers, in 2001, the average was 42.1, with 28% of fishers with less than 35 years of age. In 2011, the mean age of fishers was 44.6 and only 20% were less than 35 years old (INE 2012; INE 2016).

From an European perspective, employment in the fishing sector decreased from 676000 fishers, in 2000, to 347000, in 2014. This decrease can constitute a signal of a stabilization of commitment in the sector, which is extremely important to support particularly rural livelihoods. It was suggested a greater focus on the social-economic contributions rather than on economic contributions, since small scale fisheries (SSF) provide work to 90% of people employed in global capture fisheries (FAO 2016).

Table 2.2 – Comparison between fishers' biological knowledge about octopus in Southwest and South Coast and scientific evidences. *Calculated percentages are above 100% because fishers gave more than one answer.

		SouthWest Coast	South Coast	Scientific evidences
REPRODUCTION				
type	don't know	21%	2%	eggs (e.g. Pierce et al, 2010; Lourenço, S., 2014)
	eggs	79%	98%	
number of reproduction peaks per year	don't know	23%	-	two peaks in the Southwest Spain (e.g. Silva et al, 2002); in EU waters (e.g. Pierce et al, 2010); in Portuguese waters (e.g. Lourenço et al, 2012); one peak in Galician waters (e.g. Otero et al, 2007)
	one to three peaks	56%	67%	
	more than three peaks	9%	-	
	all the year	12%	33%	
peaks and seasons of reproduction*	don't know	19%	-	Winter and Summer (e.g. Pierce et al, 2010) in EU waters, Spring (e.g. Otero et al, 2007) in Galician waters, Spring and Summer (e.g. Silva et al, 2002) in the Southwest Spain, Early Spring and Summer in north-west coast and Summer in south coast in Portuguese waters (e.g. Lourenço et al, 2012)
	one peak	58%	69%	
	all year	12%	4%	
	spring	14%	25%	
	summer	51%	77%	
	autumn	33%	8%	
	winter	30%	31%	
location of paralarvae/juvenile	don't know	12%	-	coastal waters at short distance from coastline (e.g. Moreno et al, 2014), continental shelf (e.g. Pierce et al, 2010)
	homogeneous distribution	56%	10%	
	coastal waters	28%	85%	
	sand	5%	-	
	Far from the coast	-	4%	
longevity	don't know	65%	4%	12-14 months (e.g. Domain et al, 2002; Pierce et al, 2010)
	12-24 months	23%	67%	
	more than 24 months	12%	29%	
OTHER ASPECTS				
abundance of octopus over time	same	28%	8%	highly variable and strongly affected by environmental factors (e.g. Moreno et al, 2014, Sobrino et al, 2002); less abundance in some areas (e.g. Moreno et al, 2014)
	less	26%	60%	
	more	23%	-	
	variable over time	23%	31%	
*feeding of octopus**	crustaceans	98%	94%	crustaceans, teleost fish, other cephalops, polychaetes (e.g. Pierce et al, 2010)
	teleost fish	79%	65%	
	other cephalops	37%	10%	
*preferential habitats for octopus**	rock	93%	69%	rock, sand and mud (e.g. Silva et al, 2002; Moreno et al, 2014)
	sand	67%	75%	
	mud	30%	29%	

2.3.2. Fishers and scientific biological knowledge

Regarding biological knowledge (Table 2.2) the perception about the way octopus reproduces, by eggs is more clear among South Coast fishers (98%) than Southwest Coast fishers (79%) and no variability is present in scientific evidences. Scientific studies conducted in different geographical areas reveal different number of peaks and seasons of reproduction (e.g. Silva et al. 2002; Otero et al. 2007; Pierce et al. 2010; Lourenço et al. 2012) revealing the capacity of the species to adapt to different environmental conditions as suggested by Lourenço et al. (2012). Taking this into account, a study in the Portuguese coast (Lourenço et al. 2012) defined two spawning peaks during early Spring and Summer in the north-west coast, and one peak during the Summer in the south coast. Fishers mostly perceived a summer peak in both coasts, but more fishers from the South Coast (77%) were of this opinion than fishers from the Southwest Coast (51%). Fishers' perception mostly coincided with scientific data on the same study areas. Science identified that paralarvae are located in coastal waters, which matched the dominant answer by South Coast fishers (85%), whereas Southwest Coast fishers thought the distribution was more homogeneous (56%). Fishers from the South Coast seem to be well knowledgeable about recruitment grounds, being in agreement with a study developed in the Portuguese coast (Moreno et al. 2014), which identified that some of the most important recruitment grounds for *O. vulgaris* are near estuarine or lagoon systems. The longevity of the common octopus is scientific described as 12-14 months, which coincide with the dominant answer given by South Coast fishers (67%). Altough south coast fishers seem in general to be quite knowledgeable about the longevity of octopus, fishers from *Ferragudo* estimated a much higher longevity, believing that octopus live between 3 and 7 years. Southwest coast fishers, on the contrary, mostly didn't have an opinion about octopus longevity, with most preferring not to answer the question (65%) and only 23% considering octopus longevity to be 12-28 months, revealing again accordance with scientific knowledge. Many fishers revealed to know that this species are terminal spawners, however, there were some contrary comments, with some fishers believing that the common octopus is not a terminal spawner and live many years. Science describes the abundance of the species as being highly variable and strongly affected by environmental factors (e.g. Sobrino et al. 2002; Moreno et al. 2014), while some other authors describe abundance to have decreased in some areas (Moreno et al. 2014). The dominant answer by South Coast fishers was that octopus was less abundant nowadays (60%) while most Southwest coast fishers were of the opinion that there was no change in abundance over time (28%). All fishers' answers related to feeding habits and habitat match some of the scientific evidence, showing that fishers knowledge is in total agreement with scientific knowledge on these topics. All the fishers' answers related with feeding habits and habitat contemplate at least one of the scientific evidences, exposing a total overlap of fishers and scientific answers.

Comparing the answers obtained from fishers and scientific data, it is possible to establish a link between the biological aspects in which fishers reveal more variability in knowledge and the aspects were scientific evidence also present more variability. This is the case with respect to the number of reproduction peaks per year and reproduction periods, with both fishers knowledge and scientific knowledge being varied. As pointed out by Garcia et al (2008), it is increasingly recognized that in case of a contradiction between local and scientific knowledge, it cannot be assumed that scientific knowledge is indeed correct. An overlap between south coast fishers' knowledge and scientific studies stands out, revealing that south coast fishers have a greater knowledge about this fishery resource that they been targeting for years, than fishers from the west coast. One of the reasons that may have contributed to this increased ecological knowledge was the "Tertúlias do Polvo" initiative, developed between 2014 and 2015 by the Fisheries, Biodiversity and Conservation (FBC) group of the Centre of Marine Sciences (CCMAR) in the Algarve region, with the aim of sharing knowledge between researchers, fishers and managers. Also, a doctoral thesis (Sonderblohm 2015) and several master thesis

about octopus have been developed in south fishing ports, promoting a relationship between science and fishers over some years, which may constitute another source of knowledge transference. All the initiatives that promote a closer relation between stakeholders may develop the susceptibility of learning new concepts and accept different evidences. Furthermore, in the southwest coast many fishers commented about the lack of interest of managers to know fishers' opinions, the lack of understanding that fishers have about octopus' life cycle, lack of union in fishing communities and the need to increase communities' awareness about this resource. This might be one of the reasons for the general lower knowledge about the biology of octopus expressed by southwest fishers when compared to south coast fishers.

It is also important to emphasize the variability presented, not only between fishers' knowledge and science, but also in scientific data, as presented before. To promote more informed and accepted management decisions, fishers' knowledge and traditional scientific data should be compared and complement each other. Even if the comparison between knowledge are pointing in opposite directions, it should not automatically be assumed that fishers are wrong and scientists are right. It is necessary to understand what caused the differences and develop new studies to improve fishers' biological knowledge about the resource (Silvano & Valbo-Jørgensen 2008). There are many knowledge between scientists and local communities so, if the common ground can not be found, it can be negotiated (Wilson et al. 2006). Besides, incorporating different perceptions may provide useful information to create working hypotheses and develop shared visions (Garcia et al. 2008)

Several studies appealed to fishers' knowledge to complement scientific evidence to assess changes in ecosystems (Zukowski et al. 2011; Rosa et al. 2014) and to improve fisheries management in cases where biological data is lacking (Silvano et al. 2006). Another study developed in the eastern English Channel to assess fishers' perception about ecosystem changes, found good agreement between fishers' statements and scientific data and showed that fishers reveal a great potential as early warning signals of resource changes. They also suggested that fishers' perceptions should be used as indicators for resource managers (Rochet et al. 2008). When making linkages between LEK and science, to recognize fishers' inherent value, they should be involved in all the aspects of a study (Brook & McLachlan 2005). The real challenge is to use experiences and expertise both from scientists and fishers to deal with environmental and socioeconomic problems (Brook & McLachlan 2005).As supported by previous studies, the biological characteristics of this species and its sensitivity to environmental conditions must be considered to the development of adaptable management measures (Sonderblohm et al. 2017).

2.4. CONCLUSIONS

In conclusion, there was some overlap between fishers' LEK and scientific findings, revealing that fishers have a reasonable knowledge about the resource. Topics about which fishers reveal some heterogeneous opinions coincided with the biological features where science also revealed less robust knowledge. In our opinion, it is crucial that fishers are aware about the biological characteristics of such a singular resource to understand and respect management measures that could protect this species. Furthermore, developing of awareness in fishing communities about octopus' biological characteristics and fishers' impacts will promote more conscious fishers, mainly because of their concern to optimize catches and minimizing effort. More scientific studies to collect data would be necessary to develop knowledge transfer between scientists and fishers.

2.5. REFERENCES

Bender, M. G., Machado, G. R., De Azevedo Silva, P. J., Floeter, S. R., Monteiro-Netto, C., Luiz, O. J., and Ferreira, C. E. L. 2014. Local ecological knowledge and scientific data reveal overexploitation by multigear artisanal fisheries in the Southwestern Atlantic. PLoS ONE, 9.

Berghöfer, A., Wittmer, H., and Rauschmayer, F. 2008. Stakeholder participation in ecosystem-based approaches to fisheries management: A synthesis from European research projects. Marine Policy, 32: 243–253.

Berkes, F., George, P. J., & Preston, R. J. 1991. Co-management: the evolution of the theory and practice of joint administration of living resources. Program for Technology Assessment in Subarctic Ontario, McMaster University, 12-18

Brook, R. K., and McLachlan, S. M. 2005. On using expert-based science to 'test' local ecological knowledge. Ecology and Society, 10: 2–4.

Domain, F., Jouffre, D., and Caverivière, A. 2000. Growth of Octopus vulgaris from tagging in Senegalese waters. Journal of the Marine Biological Association of the UK, 80: 699–705.

European Commission (2017) Landings of fishery products NET 2017. Data provided by M.S. at 23/08/2017. Build of 27/09/2017

FAO. 2016. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome.200 pp. Rome. 223 pp.

Garcia, S. M., Allison, E. H., Andrew, N. J., Béné, C., Bianchi, G., de Graaf, G. J., Kalikoski, D., et al. 2008. Towards integrated assessment and advice in small-scale fisheries: Principles and processes. 101 pp.

Guyader, O., Berthou, P., Koutsikopoulos, C., Alban, F., Demanèche, S., Gaspar, M. B., Eschbaum, R., et al. 2013. Small scale fisheries in Europe: A comparative analysis based on a selection of case studies. Fisheries Research, 140: 1–13.

Huntington, H. P. 2000. Using Traditional Ecological Knowledge in Science : Methods and Applications. Ecological Applications, 10: 1270–1274.

ICES. 2014. ICES WGCEPH REPORT 2014 Report of the Working Group on Cephalopod Fisheries and Life History (WGCEPH) Lisbon , Portugal International Council for the Exploration of the Sea. Ices Cm 2014/Ssgef: 02: 16–19.

INE. 2012. Estatísticas da Pesca 2011.

INE. 2016. Estatísticas da Pesca 2016.

Lourenço, S., Moreno, A., Narciso, L., González, Á. F., and Pereira, J. 2012. Seasonal trends of the reproductive cycle of Octopus vulgaris in two environmentally distinct coastal areas. Fisheries Research, 127–128: 116–124.

Mackinson, S., and Nottestad, L. 1998. Combining local and scientific knowledge. Reviews in Fish Biology and Fisheries, 8: 481–490.

Moreno, A., Lourenço, S., Pereira, J., Gaspar, M. B., Cabral, H. N., Pierce, G. J., and Santos, A. M. P. 2014. Essential habitats for pre-recruit Octopus vulgaris along the Portuguese coast. Fisheries Research, 152: 74–85.

Msomphora, M. R. 2015. Stakeholder participation and satisfaction in the process of developing management plans: The case of Scottish Inshore Fisheries Groups. Ocean and Coastal Management, 116: 491–503.

Neis, B., Felt, L., Schneider, D. C., Haedrich, R., Hutchings, J., and Fischer, J. 1999. Northern cod stock assessment: what can be learned from interviewing resource users?, 1963: 28.

Otero, J., González, Angel F., Sieiro, M. P., and Guerra, A. 2007. Reproductive cycle and energy allocation of Octopus vulgaris in Galician waters, NE Atlantic. Fisheries Research, 85: 122–129.

Pierce, G. J., Allcock, L., Bruno, I., Jereb, P., Lefkaditou, E., Malham, S., Moreno, A., et al. 2010. Cephalopod biology and fisheries in Europe. ICES Cooperative Research Report, 303: 175.

Pita, C., Pierce, G. J., and Theodossiou, I. 2010. Stakeholders' participation in the fisheries management decision-making process: Fishers' perceptions of participation. Marine Policy, 34: 1093–1102.

Pita, C. 2014. Small-scale fisheries in Portugal:a brief overview (CERMES Technical Report 73).

Pita, C., Pereira, J., Lourenço, S., Sonderblohm, C., and Pierce, G. 2015. Interactive Governance for Small-Scale Fisheries Global Re fl ections. In Interactive Governance for Small-Scale Fisheries, pp. 117–132.

Pita, P., Fernández-Vidal, D., García-Galdo, J., and Muíño, R. 2016. The use of the traditional ecological knowledge of fishermen, cost-effective tools and participatory models in artisanal fisheries: Towards the co-management of common octopus in Galicia (NW Spain). Fisheries Research, 178: 4–12.

Rochet, M. J., Prigent, M., Bertrand, J. A., Carpentier, A., Coppin, F., Delpech, J. P., Fontenelle, G., et al. 2008. Ecosystem trends: Evidence for agreement between fishers' perceptions and scientific information. ICES Journal of Marine Science, 65: 1057–1068.

Rosa, R., Marques, A. M., Nunes, M. L., Bandarra, N., and Reis, C. S. 2004. Spatial-temporal changes in dimethyl acetal (octadecanal) levels of Octopus vulgaris (Mollusca : Cephalopoda): relation to feeding ecology. Scientia Marina, 68: 227–236.

Rosa, R., Carvalho, A. R., and Angelini, R. 2014. Integrating fishermen knowledge and scientific analysis to assess changes in fish diversity and food web structure. Ocean and Coastal Management, 102: 258–268.

Silva, L., Sobrino, I., and Ramos, F. 2002. Reproductive biology of the common octopus, Octopus vulgaris, 1791 (Cephaloopoda: Octopodidae) in the Gulf of Cadiz (SW Spain). Bulletin of Marine Science, 71: 837–850.

Silvano, R. A. M., MacCord, P. F. L., Lima, R. V., and Begossi, A. 2006. When does this fish spawn? Fishermen's local knowledge of migration and reproduction of Brazilian coastal fishes. Environmental Biology of Fishes, 76: 371–386.

Silvano, R. A. M., and Valbo-Jørgensen, J. 2008. Beyond fishermen's tales: Contributions of fishers' local ecological knowledge to fish ecology and fisheries management. Environment, Development and Sustainability, 10: 657–675.

Sobrino, I., Silva, L., Bellido Millán, J. M., and Ramos, F. 2002. Rainfall, river discharges and sea temperature as factors affecting abundance of two coastal bentic cephalopod species in ti-ie gulf of cadiz (sw spain). Bulletin of Marine Science, 71: 851–865.

Sonderblohm, C. A. P. 2015. Dinâmica das Pescas e Gestão Participativa do polvo vulgar (Octopus vulgaris) capturado pela frota de covos e alcatruzes no Sul de Portugal.

Sonderblohm, C. P., Guimarães, M. H., Pita, C., Rangel, M., Pereira, J., Gonçalves, J. M. S., and Erzini, K. 2017. Participatory assessment of management measures for octopus vulgaris pot and trap fishery from southern Portugal. Marine Policy, 75: 133–142.

Wilson, D. C., Raakjaer, J., and Degnbol, P. 2006. Local ecological knowledge and practical fisheries management in the tropics: A policy brief. Marine Policy, 30: 794–801.

Zukowski, S., Curtis, A., and Watts, R. J. 2011. Using fisher local ecological knowledge to improve management: The Murray crayfish in Australia. Fisheries Research, 110: 120–127.

3. PORTUGUESE ARTISANAL OCTOPUS FISHERS' PREFERENCES FOR MANAGEMENT

ABSTRACT

The decline of finfish stocks led to the increase of cephalopods fisheries through Europe. In southern Europe, the common octopus (*Octopus vulgaris)* dominates the catches and landings in several countries, both in terms of weight and value. In Portugal, small-scale fisheries have been targeting the common octopus for a long time and is consistently one of the most important resources in the country. In Portugal, the management of octopus fishery is done mainly through measures controlling the minimum landing weight and gears. To explore octopus artisanal fishers' preferences for management measures a questionnaire was developed and conducted in several fishing ports in the northwest, south and southwest coasts of Portugal. Fishers are not satisfied with the current management of the octopus fisheries. Some differences in preferences for management measures were found between regions but in general interviewed fishers, in both regions, strongly supported biological closures and local management plan developed by fishers. Also, they were mostly of the opinion that a management plan should not be exclusively developed by fishers. Considering fishers' opinions and preferences in the decision-making process may increase their receptivity and acceptance of management measures, as well as increase their feeling of responsibility towards the resource.

KEYWORDS: Fisheries management; *Octopus vulgaris*; fishers participation, co-management; Portugal

3.1 INTRODUCTION

Cephalopods fisheries have grown and expanded through European coastlines primarily due to the decline of finfish resources. France, Portugal, Spain and the UK have been responsible for most European landings (Pierce et al. 2010). Total cephalopod landings (including landings by non-European countries) have increased from 30 000 t annually, in 1950, to 120 000 t, in 2010, to 656 000 t, in 2014 (European Comission, 2017). The common octopus (*Octopus vulgaris*), mostly target in southern Europe, has dominated landings in weight and value over time (Pierce et al. 2010).

Cephalopod fisheries in the European Union (EU) is absent of quota-management and each Member-State is responsible for implementing its own management rules. Some countries have a well-established consultation process through participation of the fishing sector and other less so. The most representative example of a well-established participatory process is Galicia, in Spain, where the octopus fishery has been managed at the regional level for over 20 years, becoming a reference point of a co-management framework (Pierce et al. 2010). In Portugal, management is done top-down mostly employing input and output control measures, with little participation from the fishing industry in the decision-making process (Pita et al. 2015).

In Portugal, the common octopus ranks as the most important target in value, representing 18% of the total value landing and the fourth most important fisheries resource in terms of quantities landing, after chub mackerel, horse mackerel and sardine, and represents 9% of national landings. (INE, 2016). In Portuguese waters, the common octopus is mainly targeted by the artisanal (or small scale) fleet using traps and pots, with this fleet being responsible for over 90% of landings (Pilar-Fonseca et al. 2014). This fishery is considerably important for coastal communities due to its socio-economic relevance. Octopus has been a traditional fishery primarily in the south but nowadays this resource supports small-scale fishing communities all over the Portuguese coast (Pita et al. 2015). In the last 20 years, the

exploitation of octopus in Portugal increased 50%, mainly motivated by the depletion of many finfish stocks (Moreno et al. 2014).

Management measures applied to the octopus fishery in Portugal are mainly related to minimum landing weight (specimen weight) and the gear used. Legislation stipulates 750g as the minimum landing weight for octopus. Gear measures are related with the number of traps per boat, baited or non-baited. A maximum of 3000 non-baited pots per vessel are defined (independent of size). Baited traps limit is related to vessel length: 750 traps per vessel under 9 meters, 1000 traps per vessels between 9 and 12 meters, and 1250 traps per vessel over 12 meters. There are also restrictions to mesh size and trap dimension. Regional management measures are also applied in the south coast fishing grounds (Algarve region), such as the prohibition of using live bait (common green crab, *Carcinus maenas*) (Pita et al. 2015).

Conventional fisheries assessment had reveal that was not able to provide the basis to informed management decisions in the small-scale subsector. Current assessment methods have failed as they often neglect to integrate important aspects of the fishery system. As a consequence, small-scale fisheries are characterized by overexploitation of coastal fishery resources and neglected fishing communities (Garcia et al. 2008). The social and economic dependence of the sector needs to be considered in the development of fisheries policies due to the fact that careful assessment is vital to support the livelihoods of fishing communities (Chuenpagdee et al. 2006). Therefore, FAO and the WorldFish Center developed an Integrated Assessment and Advisory (IAA) framework for small-scale fisheries, that affirms the participation of stakeholders, supports the need to understand social, economic and ecological system and reinforces the need of an adaptive management (Garcia et al. 2008). Also, the involvement of stakeholders in the development of management measures provides a sense of worth that may cultivate a greater responsibility of fishers towards the resource. Furthermore, the continued information shared may create conditions for co-management (Mackinson & Nottestad 1998). It is also important to take into account that resource users develop a detailed understanding of resource populations, which can be useful in the development of local management plans (Neis et al. 1999). As reported by Garcia-Allut et al. (2003), some examples of top-down measures implemented in Galician artisanal fisheries, ignoring fishers knowledge within their field of experience have proved to be inefficient, and led to fishers disrespect these measures (García-Allut et al. 2003).

Several studies have been developed around the world to assess fishers participation in management decisions. A study developed in California tested stakeholder preferences for two distinct approaches to establish Marine Protected Areas (MPAs). Results revealed that stakeholder preferences for a decision-making approach is influenced by their convictions (Weible et al. 2004). Linke and Bruckmeier (Linke & Bruckmeier 2015) indicate that multi-dimensional problems appear in fisheries management and co-management which reveals its complexity and uncertainty. As such, the concept of fisheries co-management as a solution to resource use problems should be part of the efforts to achieve social, economic and ecological sustainable resource use (Linke & Bruckmeier 2015). However, despite the complexity of a co-management system, it has been suggested that the key issue is a dual approach. One in which authorities provide incentives for conservation based on fishers' rights and supported by strong management with legal enforcement and harvest strategies (Beddington et al. 2007).

The present study aims to analyse Portuguese artisanal octopus fishers' preferences for management measures, and contribute to provide data for decision-makers to develop management measures which will be accepted by fishers and further involve fishers in a future management framework.

3.2. METHODS

3.2.1. Study areas and survey

Due to the importance of octopus as a fishing resource to small-scale fishing communities all over the Portuguese coast, the present study was conducted in three different regions of the Portuguese coast, specifically in 14 fishing ports (Aveiro, Cascais, Sesimbra, Sines, Sagres, Lagos, Alvor, Portimão, Ferragudo, Albufeira, Quarteira, Olhão, Fuzeta and Santa Luzia) (Figure 3.1). Most ports are in the south as the artisanal fleet has been historically dependent on this resource in the south, targeting octopus since 1970s.

To assess fisher's perception about and preferences for several management measures, inquiries were conducted in the 14 fishing ports.

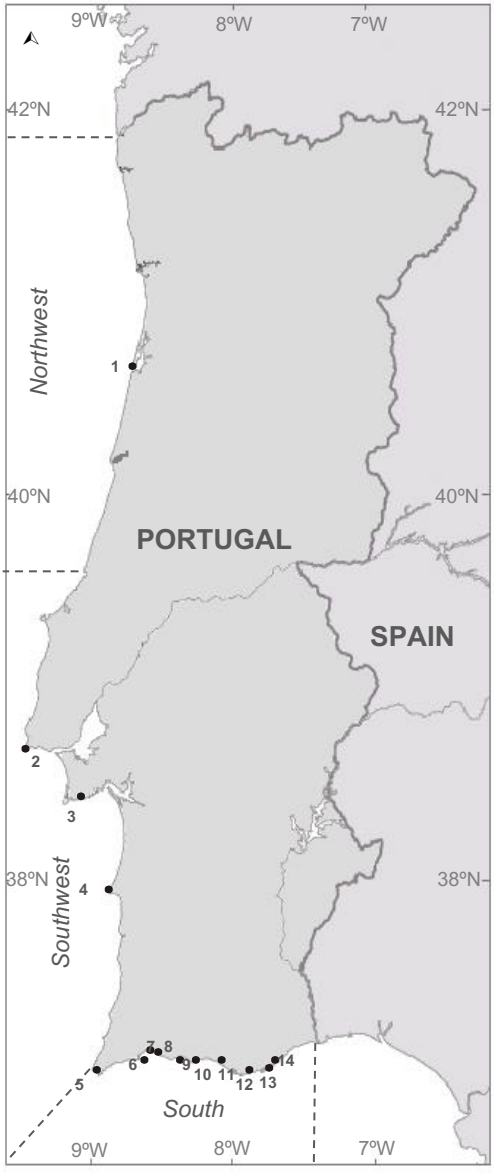

Figure 3.1 - Map of mainland Portugal with fishing ports where intervews were conducted (1-Aveiro, 2-Cascais, 3-Sesimbra, 4-Sines, 5-Sagres, 6-Lagos, 7-Alvor, 8-Portimão, 9-Ferragudo, 10-Albufeira, 11-Quarteira, 12-Olhão, 13-Fuzeta, 14-Santa Luzia)

The questionnaire was developed with different sections in order to collect information about demographic characteristics, the fishing activity and opinion about management measures. In the section about demographic characteristics fishers were asked about age, experience fishing, years of schooling, economic dependence of fisheries (if they only worked on fisheries), and dependence on octopus. In the section about fishing activity, questions asked were related to their role on board, number of fishers working onboard, boat size, type of gear they operate (pots, traps or other), number of pots/traps in the water, number of days worked per week, and amount of octopus fished per day. In the section about management measures, fisheries were asked to rank several management measures in a five-point Likert-scale, ranging from very important to irrelevant. Measures included implementation of a biological closure, implementation of fishing schedules or weekend stops, definition of a quota per boat, increasing the minimum landing weight, reduction of fishing effort, develop of a local management plan for octopus, creation of a local certification of origin, development of a management plan by fishers, increasing of control/surveillance, and implementation of a system of control/surveillance carried out by fishers. Fishers were also asked about their satisfaction with the current octopus management system, the main reasons for the failure of management measures, their interest in being involved in the development of a management plan for octopus, reason to be or not involved, and if the management plan should be exclusively developed by fishers. The surveys were carried out through face to face interviews that were conducted in different moments, from November 2014 to December 2016,

resulting in a total of 208 interviews. Fishers were approached randomly in the harbour and one interview was carried out per boat. Questionnaires have a large set of common questions, but in some cases, additional questions were made, taking into consideration particular and subsidiary interests for some of the fishing ports.

3.2.2. Data analysis

The descriptive analyses were carried out separately for the different regions of the Portuguese coast to compare the preferences and opinions of fishers from the different areas. As such, fishing ports were aggregated in three regions as indicated in Figure (northwest, southwest and south). Differences between fishers' preferences and opinions about the several management measures that may apply to octopus artisanal fisheries, were tested with chi-square tests. Comparisons between groups were carried out using a Bonferroni corrections to counter the effects of multiple testing. Due to the small sample size, and for the purposes of the analysis, the ordinal data, measured with the five-point Likert-scale, was collapsed to two points (very important, other) as suggested by Pita et al (2013). All statistical analyses were conducted with STATA SE 10 (Data Analysis and Statistical Software, STATA Corp., College Station, Texas, USA).

3.3. RESULTS

3.3.1. Demographic and fishing characteristics

Fishers from the different regions shared similar characteristics (Table 3.1). In the three regions, the mean age was identical, revealing middle-age fishers with a vast experience fishing, and a low level of formal education. Also, in the three regions, fishers were highly dependent on the fishing activity and only a small percentage had another source of income. Interviewed fishers present a very high dependence on the octopus fishery. Regarding the fishing activity, the average number of fishers onboard were the same in the southwest and south coast, but higher in the northwest coast. The same happened when comparing the number of days worked per week. In the southwest and south coasts most interviewees were skippers while in the northwest most interviewees were part of the crew or owners of the boat. Evaluating the type of gear used, similar characteristics could be found again between the southwest and south coasts, where the use of traps dominated. In the northwest coast the use of pots was dominant and there was also a small percentage of fishers (18%) that use another type of gear called *"piteira",* which consists of a cable with hooks. The number of pots/traps in the water were higher in the south coast and less in the northwest coast. Comparing the amount of octopus fished per fishing day, northwest cost fishers report to capture higher quantities while similar quantities were reported by fishers from the southwest and south coasts.

Table 3.1 – Characteristics of fishers and fishing activity in different regions of Portuguese coast. Data are shown as mean (± standard deviation) or percentages

Variables	Northwest Coast (n=44)	Southwest Coast (n=43)	South Coast (n=121)
Demographic characteristics			
age (mean ± sd) (years)	46 ± 7	52 ± 11	47 ± 11
experience fishing (mean± sd) (years)	25 ± 9	34 ± 16	27 ± 13
years of schooling (mean ± sd)	6 ± 1	6 ± 1	6 ± 1
fishers economic dependence of fishing (% totally fisheries)	98	84	84
fishers totally dependent on octopus fishing (%)	100	98	85
Fishing activity			
boat size (mean ± sd) (m)	11.7 ± 3.9	8.5 ± 2.8	9.2 ± 2.3
fleet (%)			
local	61	77	53
coastal	39	23	45
number of employees related with the boat (mean ± sd)	6 ± 3	3 ± 1	3 ± 1
work days per week (mean ± sd)	5 ± 1	4 ± 1	4 ± 1
role on board (%)			
skipper	14	65	74
other	86	35	26
type of gear (%) *			
traps	55	95	93
pots	75	9	18
other	18	-	2
number of pots/traps in the water (mean ± sd)	473 ± 267	926 ± 918	1040 ± 756
weight of octopus fished per day (mean ± sd) (kg)	187.4 ± 207.1	102.4 ± 60.8	102.1 ± 58.5

** Some fishers selected more than one option, as such values sum more than 100%*

3.3.2. Management measures and management plan

Regarding management measures, fishers were asked about their opinion about different measures (Table 3.2). The measures with greater acceptance by all fishers was the development of a management plan by fishers (81%), and the implementation of a biological closure (81%). On the other hand, the measures with less acceptance were the implementation of a control/surveillance system by fishers (30%) and the implementation of a fishing schedule (32%).

Perceptions about several management measures varied significantly between fishers from the different regions. While northwest (98%) and south (86%) coast fishers largely perceived biological closures as a very important management measure, the former group actually perceiving this as the most important measure of all, fishers from the southwest coast had a significant different opinion about this measure (49%; p-value<0,001). Implementation of fishing schedule (e.g. weekend stops) had a lower acceptance (32%) The definition of a quota per boat was more accepted by northwest coast fishers (80%), which expressed an opinion statistically significantly different from southwest (36%) and south (49%) fishers, who did not consider this measure particularly important.

Increasing the minimum landing weight had a lower acceptance by all fishers (23%), the development of a local management plan for octopus and the increasing of control/surveillance had a low acceptance by all fishers (<50%). While reducing fishing effort (e.g. number of traps or fishing licenses) was not well accepted by northwest coast fishers (16%), but southwest (58%) and south (55%)

coast fishers consider the measure to be very important. The creation of a certification of origin had a high acceptance by all fishers (79%).

The development of a management plan by fishers was often mentioned as an important management approach (81%), this approach was significantly more popular amongst south coast fishers than southwest coast fishers (p-value<0.05). Fishers' opinions about the implementation of a control/surveillance system by fishers (30%) was significantly different (p-value<0.01) between southwest and south coast fishers.

Analysing fishers' opinions about the current management of octopus fisheries (Table 3.3), northwest coast fishers were very dissatisfied with the current management (95%). South coast fishers were also of the same opinion, whereas in southwest fishers had more divided opinions on this matter. Fishers from all regions reported to be interested in the development of a local management plan, which they considered that should not be exclusively developed by fishers. Regarding being involved in the management plan, northwest coast fishers were very interested in being involved (89%) while southwest coast fishers (30%) and in southwest coast fishers (47%) declared not to be so interested. Different reasons were pointed out by fishers to want to be involved (or not). Reasons given by fishers to want to be involved, were to increase education and awareness for most northwest coast fishers (29%), to contribute with fishers' knowledge for most southwest coast fishers (64%) and to increase fishers' participation in management for most south coast fishers (41%). Reasons to not want to be involved were also identified, and these included the lack of interest for southwest coast fishers (36%) and northwest coast fishers (50%), the lack of time for south coast fishers (37%) and the fact that fishers were tired with the lack of results from previous participation for northwest coast (50%).

Table 3.2 –Fishers preferences for management measures. Data are shown as the percentages of fishers that evaluate the measure as very important. Individual statements were tested for significant differences between fishers from different coasts with Chi-square tests (or Fisher's exact test when assumptions are not meet by the data).

Management measures	Northwest Coast (n=44) (%)	Southwest Coast (n=43) (%)	South Coast (n=121) (%)	Statistics	All (%)
Implementation of a biological closure	98 [a]	49 [a,b]	86 [b]	Fisher's exact <0.001	81
Implementation of fishing schedule (e.g., weekend stops)	14	37	37	$\chi2$ (2) = 6.68, p=0.03	32
Definition of a quota per boat	80 [a,b]	36 [b]	49[a]	$\chi2$ (2) = 2.51, p=0.28	53
Increasing the minimum landing weight	-	19	25	$\chi2$ (1) = 0.64, p=0.43	23
Reduce of fishing effort (number of traps/fishing licenses)	16 [a,b]	58 [b]	55[a]	$\chi2$ (2) = 5.37, p=0.07	47
Development of a local management plan for octopus	-	39	51	$\chi2$ (1) = 1.35, p=0.25	48
Creation of local certification of origin logo	-	79	79	$\chi2$ (1) = 0.002, p=0.96	79
Development of a management plan by fishers	-	67	86	$\chi2$ (1) = 7.19, p=0.01	81
Increasing of control/surveillance	39	35	49	$\chi2$ (2) = 0.10, p=0.95	44
Implementation of control/surveillance system by fishers	21	12[a]	40 [a]	$\chi2$ (2) = 9.21, p=0.01	30

[a, b] *the regions that are statistically significantly different share the same letter. Post-hoc estimation was calculated with Bonferroni correction for multiple comparisons*

Table 3.3 – The opinion of fishers about management plan and several issues related in different regions of Portuguese coast. Data are shown as percentages

Management	Northwest Coast (n=44)	Southwest Coast (n=43)	South Coast (n=121)
satisfied with actual management (%)			
no	95	33	50
yes	5	40	44
maybe	-	28	6
interested in the development a local management plan (%)			
no	-	-	15
yes	-	88	79
maybe/don't know	-	12	7
interested in being involved in a local management plan (%)			
yes	89	30	47
other answers	11	70	53
management plan should be exclusively developed by fishers (%)			
no	-	79	60
yes	-	21	39
reasons to be involved in the development of a local management plan (%)			
protect interests	11	29	31
more proximity between fishers and authorities	16	-	-
contribute with fishers' knowledge	18	64	28
increase fisher's participation	5	-	41
Education and awareness	29	7	-
don't know	21	-	-
reasons to not be involved in the development of a local management plan			
lack of time	-	12	37
lack of age/near retirement	-	28	16
lack of capacity	-	4	16
without interest	50	36	16
tired of no results	50	4	9
conflicts between fishers	-	16	5
reasons for management failure (%) *			
fishers don't respect management measures	45	55	67
poor measure	88	52	17
unrealistic measure	88	74	28
lack of surveillance	26	10	28

** some fishers selected more than one option, as such values sum more than 100%*

3.4. DISCUSSION

Nowadays, octopus fishery supports small-scale fishing communities all over the Portuguese coast, representing a source of guarantee income for most small-scale fishers (Pilar-Fonseca et al. 2014). Fishers in the study were highly dependent on fishing and in the resource octopus, which is in agreement with findings from (Sonderblohm et al. 2017), who also noticed this trend in the Algarve region. It is important to considered that demographic and business characteristics (work experience age, education, fisheries dependency) can influence stakeholder participation and their satisfaction need to increase in order to increase their participation (Msomphora 2015).

Fishers showed a preference for biological closures, management plans developed by fishers, and the creation of local certification of origin. Temporal closures have been widely used as a management option, as it may be a reasonable approach to maintain a higher spawn biomass and more easily enforced and controlled (Myers et al. 2000; Fernández-Rueda & García-Flórez 2007). In the case of octopus, this measure was found to be effective for a balanced exploitation (together with the increase of minimum landing weight of 1000g per specimen) in Galicia (Fernández-Rueda & García-Flórez 2007). Nevertheless, the authors point to the fact that octopus landings must be monitored to find indicators of variations in spawning season allowing managers to vary the closed season to protect next generation (Fernández-Rueda & García-Flórez 2007). Fishers defended that this measure should be implemented during spawning peaks to protect young recruits from fishing, however, this should be adapted to each region, since both biological and environmental variability is high (Silva et al. 2002; Otero et al. 2007; Lourenço et al. 2012).

Regarding the potential implementation of a co-management plan, this should attract a broad range of stakeholders and representatives of the state, market and civil society. Moreover, this process can be initiated top-down or bottom-up, in the case of being trigger by, for example, fishers (Chuenpagdee & Jentoft 2007). The efficiency of users as participants in the decision-making process depends on their capacity to coordinate strategies and speak as one. The more united fishers are, more difficult it will be for government disregard their advice (Jentoft & McCay 1995). However, in the present study, one of the problems most commented by fishers was the lack of union/association between fishers of the same fishing port, a fundamental feature to take their opinion forward. Nonetheless, it was noticed during intervews that fishers have difficulties to reach agreements and consensus among them. Therefore, in a future case, a greater effort must be made to promote unity between fishers to their involvement in the decision-making process. A common and particular goal may be viewed as a tool for a more unanimous positioning, namely ecolabels of fisheries products. Usually, ecolabeled products are sold at higher prices and it can play a role in changing the way resources are extracted from the sea by modifying the behaviour of participants along the supply chain (Kaiser & Edwards-Jones 2006).

Portuguese artisanal octopus fishers were not satisfied with current management of octopus (mainly related with landing weight and gears), and think a that a management plan should be developed for octopus, but only northwest coast fishers manifested an interest in being involved in such development. The main reasons pointed out by fishers from the two other regions to not be involved was the lack of time and interest. Otherwise, fishers were motivated by the will of contribute with fishers' knowledge, increase fishers' participation and increase education and awareness. However, most fishers were of the opinion that that the management plan should not be developed solely by fishers. The combination of these factors could create an opportunity for co-management.

The reasons pointed out for management failure, were predominantly unrealistic measures, lack of respect of management measures by fishers and the establishment of poor measures since the beginning. Besides that, general comments from fishers revealed a dissatisfaction with the current situation of octopus' management in Portugal, mainly due to the lack of realistic management measures, fishers' absence from the process and with the monitoring and control system. As also reported by another study (Sonderblohm et al. 2017) many fishers from the regions admitted that far more traps are used than what is allowed by law, meaning that limitations defined by law have been largely bypassed and ignored, also revealing a lack of control. If fishers feel excluded from the process, they are more likely to be dissatisfied with the management process (Msomphora 2015). Likewise fishers will be more receptive to local management and conservation efforts when their experience is considered (Mackinson & Nottestad 1998; Neis et al. 1999; Bender et al. 2014; Pita et al. 2015), and their involvement is probably the only way to increase compliance with regulations

(Pita et al. 2015). All the previous studies referred defend the involvement of fishers in the decision-making process of the activity on which they depend. Moreover, the interest in engaging stakeholders in the management of fisheries has grown (Berkes et al. 1991; Freire & García-Allut 2000; Suárez de Vivero et al. 2008; Nielsen et al. 2015). Around Europe, fisheries management presents differences and similarities. In countries like Denmark and Norway decision-making is relatively centralised but with a strong part of stakeholder consultation. In other countries like France, Netherlands and specially Spain, consultation processes were introduced within a framework. Despite consultation being widespread, real delegation of decision-making power to stakeholders is inexistent (except for Spain and Netherlands) (Mikalsen & Jentoft 2008). Some attempts have been developed worldwide in order to assess fishers' preferences for management restrictions (Mcclanahan et al. 2012), and the attitudes towards closed areas (Pita et al. 2013).

As supported by Pita et al (2015), considering the social-economic dependence of Portuguese small-scale fishing communities on octopus, more attempts should be developed to promote more appropriate stock assessments with the cooperation of the fishing industry. It is also fundamental to considered that this species has particular characteristics: semelparity, a short life cycle, no overlap generations and wide interannual fluctuations in abundance (due to susceptibility to environmental factors) (Pierce et al. 2010). All these features make the management of this resource a real challenge (Pita et al. 2015).

3.5. CONCLUSIONS

Portuguese artisanal octopus fishers are not satisfied with the current management of the octopus fisheries. In general, fishers from different regions have different opinions and preferences for management measures for octopus, but in general biological closures and the implementation of a management plan developed by fishers were well accepted by all fishers. Fishers also showed an interested in the development of a management plan for the octopus fishery, and some would be interested in being involved in management (mainly in the northwest). Also, they were mostly of the opinion that a management plan should not be exclusively developed by fishers. The combination of these factors show an openness for co-management. In the near future, the involvement of fishers in decision-making process should be promoted as it can lead to a successful management plan. As defended by different authors, fishers are more likely to not feel satisfied with management if they are absent from the process and their participation will cause the increase of their receptivity to management (Mackinson & Nottestad 1998; Murray et al. 2006; Bender et al. 2014; Pita et al. 2015). Furthermore, understanding fishers' perceptions and opinion about management plan will facilitate planning and development of management measures.

3.6. REFERENCES

Beddington, J. R., Agnew, D. J., and Clark, C. W. 2007. Current problems in the management of marine fisheries. Science (New York, N.Y.), 316: 1713–1716.

Bender, M. G., Machado, G. R., De Azevedo Silva, P. J., Floeter, S. R., Monteiro-Netto, C., Luiz, O. J., and Ferreira, C. E. L. 2014. Local ecological knowledge and scientific data reveal overexploitation by multigear artisanal fisheries in the Southwestern Atlantic. PLoS ONE, 9.

Berghöfer, A., Wittmer, H., and Rauschmayer, F. 2008. Stakeholder participation in ecosystem-based approaches to fisheries management: A synthesis from European research projects. Marine Policy, 32: 243–253.

Berkes, F., George, P. J., & Preston, R. J. 1991. Co-management: the evolution of the theory and practice of joint administration of living resources. Program for Technology Assessment in Subarctic Ontario, McMaster University, 12-18

Chuenpagdee, R., Liguori, L., Palomares, M. L. D., and Pauly, D. 2006. Bottom-Up, Global Estimates of Small-Scale Marine Fisheries Catches. Fisheries Centre Research Reports, 14: 105.

Chuenpagdee, R., and Jentoft, S. 2007. Step zero for fisheries co-management: What precedes implementation. Marine Policy, 31: 657–668.

European Commission (2017) Landings of fishery products NET 2017. Data provided by M.S. at 23/08/2017. Build of 27/09/2017

FAO. 2016. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome.200 pp. Rome. 223 pp.

Fernández-Rueda, P., and García-Flórez, L. 2007. Octopus vulgaris (Mollusca: Cephalopoda) fishery management assessment in Asturias (north-west Spain). Fisheries Research, 83: 351–354.

Freire, J., and García-Allut, A. 2000. Socieconomic and biological causes of management failures in european artisanal fisheries: Marine Policy, 24: 375–384.

García-Allut, A., Freire, J., Barreiro, A., and Lousada, D. 2003. Methodology for integration of fisher's ecological knowledge in fisheries biology and management using knowledge representation (artificial intelligence). *In* 'Putting Fisher's Knowledge to Work', pp. 227–237.

Garcia, S. M., Allison, E. H., Andrew, N. J., Béné, C., Bianchi, G., de Graaf, G. J., Kalikoski, D., *et al.* 2008. Towards integrated assessment and advice in small-scale fisheries: Principles and processes. 101 pp.

Himes, A. H. 2007. Performance indicators in MPA management: Using questionnaires to analyze stakeholder preferences. Ocean and Coastal Management, 50: 329–351.

Jentoft, S., and McCay, B. 1995. User participation in fisheries management. Marine Policy, 19: 227–246.

Kaiser, M. J., and Edwards-Jones, G. 2006. The role of ecolabeling in fisheries management and conservation. Conservation Biology, 20: 392–398.

Linke, S., and Bruckmeier, K. 2015. Co-management in fisheries - Experiences and changing approaches in Europe. Ocean and Coastal Management, 104: 170–181.

Lourenço, S., Moreno, A., Narciso, L., González, Á. F., and Pereira, J. 2012. Seasonal trends of the reproductive cycle of Octopus vulgaris in two environmentally distinct coastal areas. Fisheries Research, 127–128: 116–124.

Mackinson, S., and Nottestad, L. 1998. Combining local and scientific knowledge. Reviews in Fish Biology and Fisheries, 8: 481–490.

Mcclanahan, T. R., Abunge, C. A., and Cinner, J. E. 2012. Heterogeneity in fishers' and managers' preferences towards management restrictions and benefits in Kenya. Environmental Conservation, 39: 357–369.

Mikalsen, K. H., and Jentoft, S. 2008. Participatory practices in fisheries across Europe: Making

stakeholders more responsible. Marine Policy, 32: 169–177.

Moreno, A., Lourenço, S., Pereira, J., Gaspar, M. B., Cabral, H. N., Pierce, G. J., and Santos, A. M. P. 2014. Essential habitats for pre-recruit Octopus vulgaris along the Portuguese coast. Fisheries Research, 152: 74–85.

Msomphora, M. R. 2015. Stakeholder participation and satisfaction in the process of developing management plans: The case of Scottish Inshore Fisheries Groups. Ocean and Coastal Management, 116: 491–503.

Murray, G., Neis, B., and Johnsen, J. P. 2006. Lessons learned from reconstructing interactions between local ecological knowledge, fisheries science, and fisheries management in the commercial fisheries of Newfoundland and Labrador, Canada. Human Ecology, 34: 549–571.

Myers, R. A., Fuller, S. D., and Kehler, D. G. 2000. A fisheries management strategy robust to ignorance: rotational harvest in the presence of indirect fishing mortality. Canadian Journal of Fisheries and Aquatic Sciences, 57: 2357–2362.

Neis, B., Felt, L., Schneider, D. C., Haedrich, R., Hutchings, J., and Fischer, J. 1999. Northern cod stock assessment: what can be learned from interviewing resource users?, 1963: 28.

Nielsen, K. N., Holm, P., and Aschan, M. 2015. Results based management in fisheries: Delegating responsibility to resource users. Marine Policy, 51: 442–451.

Otero, J., Gonzalez, Angel F., Sieiro, M. P., and Guerra, A. 2007. Reproductive cycle and energy allocation of Octopus vulgaris in Galician waters, NE Atlantic. Fisheries Research, 85: 122–129.

Pierce, G. J., Allcock, L., Bruno, I., Jereb, P., Lefkaditou, E., Malham, S., Moreno, A., *et al.* 2010. Cephalopod biology and fisheries in Europe. ICES Cooperative Research Report, 303: 175.

Pilar-Fonseca, T., Campos, A., Pereira, J., Moreno, A., Lourenço, S., and Afonso-Dias, M. 2014. Integration of fishery-dependent data sources in support of octopus spatial management. Marine Policy, 45: 69–75.

Pita, C., Theodossiou, I., and Pierce, G. J. 2013. The perceptions of Scottish inshore fishers about marine protected areas. Marine Policy, 37: 254–263.

Pita, C. 2014. Small-scale fisheries in Portugal:a brief overview (CERMES Technical Report 73).

Pita, C., Pereira, J., Lourenço, S., Sonderblohm, C., and Pierce, G. 2015. Interactive Governance for Small-Scale Fisheries Global Re fl ections. *In* Interactive Governance for Small-Scale Fisheries, pp. 117–132.

Silva, L., Sobrino, I., and Ramos, F. 2002. Reproductive biology of the common octopus, Octopus vulgaris, 1791 (Cephaloopoda: Octopodidae) in the Gulf of Cadiz (SW Spain). Bulletin of Marine Science, 71: 837–850.

Sonderblohm, C. P., Guimarães, M. H., Pita, C., Rangel, M., Pereira, J., Gonçalves, J. M. S., and Erzini, K. 2017. Participatory assessment of management measures for octopus vulgaris pot and trap fishery from southern Portugal. Marine Policy, 75: 133–142.

Suárez de Vivero, J. L., Rodríguez Mateos, J. C., and Florido del Corral, D. 2008. The paradox of public participation in fisheries governance. The rising number of actors and the devolution process. Marine Policy, 32: 319–325.

Weible, C. M., Sabatier, P. a., and Lubell, M. N. 2004. A Comparison of a Collaborative and Top-Down Approach to the Use of Science in Policy: Establishing Marine Protected Areas in California. Policy Studies Journal, 32: 187–207.

4. FINAL REMARKS

Fishers communities along Portuguese coast revealed and aged working force, with low level of education and a long working experience. Fishers were heavily dependent on fishing activity and report to have a family tradition in fisheries. The combination of an aging community and the lack of young fishers may lead to the reduction of local and small scale communities in Portuguese coast. Regarding fisheries assessment, conventional methods had reveal that were not able to provide the basis to informed management decisions in the small-scale subsector. The present dissertation exposed that fishers have a moderate knowledge about the resource and the biological features which reveal some heterogeneous opinions coincided with topics where science also reveal less robust knowledge.

It was also concluded that Portuguese artisanal octopus fishers were not satisfied with the current management framework. In general, fishers from different regions have different opinions but, biological closures and the implementation of a management plan developed by fishers were accepted by all fishers. Also, they were mostly of the opinion that a management plan should not be exclusively developed by fishers. The combination of these factors could create an opportunity for co-management, that should not be ignored.

It is also suggested the development of awareness actions in fishing communities. If fishers hold more knowledge about biological characteristics and fishers' impacts, they will be more conscious and respect management measures. Furthermore, more scientific studies to collect data would be necessary to develop knowledge transfer between scientists and fishers.

In conclusion, the present work demonstrated that it is necessary to create opportunities to knowledge transfer between scientists and fishers, not only to promote more informed fishers, but also to collect users' information that could facilitate successful plan. The development of management measures should contemplate fishers' participation to increase their receptivity. In a recent future, more efforts should be made to the development of a co-management plan to such a singular species.

Annex A – Questionnaire

Pesca do Polvo

Este estudo tem por objetivo caracterizar a pesca do Polvo em Portugal. Os dados destinam-se somente a fins académicos. O seu nome nunca será pedido ou revelado e os resultados serão tratados em total confidencialidade.

Data _____ Local/porto _____

Secção A: Informação sobre a pesca

1. Qual é a sua função a bordo? Mestre .. ☐ Tripulante/Pescador.. ☐ Outro.. ☐ Se outro, qual?_____
2. A sua pesca (escolha as que se aplicam):

Local covos	☐	Costeira covos	☐	Arrasto local	☐
Local alcatruzes	☐	Costeira alcatruzes	☐	Arrasto costeiro	☐

3. Quantas teias tem na água? _____ nº
   3.1 De quantos em quantos dias levanta as teias? _____ dias
4. Tamanho da sua embarcação? _____ m
5. Número de pessoas na embarcação? _____ nº
6. De um modo geral, quantos dias pesca por semana? (Se possível Inverno e Verão separado)
   Inverno: _____nº Verão: _____ nº TOTAL: _____nº
7. De um modo geral, quantos kg pesca por dia? Total: _____ kg Polvo: _____ kg
8. Em média, quanto pesam os polvos que costuma apanhar ? _____ kg
9. Em que local pesca habitualmente? (MAPA) _____
10. De um modo geral onde vende a sua pescaria? Em que lota? A quem?_____
11. Vende neste local/lota/pessoa/empresa por algum motivo em especial?_____

_____
_____
_____
_____

Secção B: Conhecimento da Ecologia do Polvo

12. Sabe como é que o polvo se reproduz ? Sim ☐ Não ☐ Se sim, como? _____
13. E quantas vezes por ano? _____
14. Qual é a época de reprodução?_____
15. Em que zona estão os juvenis? (MAPA)_____
16. Sabe quanto tempo vive o polvo? _____ anos
17. Acha que cada vez há mais ou menos polvo ?_____
18. Sabe do que é que o polvo se alimenta ? _____
19. Que tipos de fundos o polvo prefere? _____

_____
_____
_____
_____

Secção C: Opinião acerca de medidas de gestão:

20. Na sua opinião, quais são os principais problemas da pequena pesca (pesca local e costeira) em geral? _____

21. Vê um futuro para a pequena pesca? Sim ☐ Não ☐

22. Quais são as suas principais preocupações em relação ao futuro? _____

23. Acha que a nova Politica Comum da Pesca vai afetar a pequena pesca?
Não ☐ Sim ☐ Talvez ☐ Não sei ☐

*23.1*De que modo? _____

24. Em relação à pesca do polvo, está satisfeito com a maneira como está a ser gerida?
Não ☐ Sim ☐ Talvez ☐ Não sei ☐

25. Por favor classifique cada uma das seguintes medidas de gestão em relação à sua importância para a pesca do polvo.

	Muito importante	Importante	Pouco importante	Irrelevante	**Não sei**
1. Implementação de defeso	❑	❑	❑	❑	❑
2. Implementação de dias de pesca (ex. paragem ao fim-de- semana)	❑	❑	❑	❑	❑
3. Implementação de horário de pesca (ex. só permitido pescar durante o dia)	❑	❑	❑	❑	❑
4. Quotas de pesca por embarcação (ex. máximo capturas diárias) 4.1 Se Muito Importante/ Importante: valor da quota? _____ kg	❑	❑	❑	❑	❑
5. Áreas fechadas a certas pescarias (ex. arrasto)	❑	❑	❑	❑	❑
6. Aumentar o peso mínimo 6.1. Se Muito Importante/ Importante: para quanto? _____ kg	❑	❑	❑	❑	❑
7. Manter o peso mínimo de captura (750g)	❑	❑	❑	❑	❑
8. Diminuir esforço de pesca (ex. nº de armadilhas, licenças)	❑	❑	❑	❑	❑
9. Criar/definir legislação para pescaria do polvo a nível local	❑	❑	❑	❑	❑
10. Implementação um processo de certificação para o polvo local	❑	❑	❑	❑	❑
11. Definir um plano de gestão feito pelas comunidades de pescadores	❑	❑	❑	❑	❑
12. Criar um grupo de trabalho exclusivo para a pesca do polvo entre as várias associações	❑	❑	❑	❑	❑
13. Aumentar a fiscalização para a pesca do polvo (ex. nº de artes, utilização de isco, captura de indivíduos abaixo do peso médio)	❑	❑	❑	❑	❑
14. Começar um sistema de fiscalização feita por pescadores	❑	❑	❑	❑	❑

Plano de gestão para o polvo:

26. Gostaria de ver um plano de gestão para o polvo na sua zona?
Não ☐ Sim ☐ Talvez ☐ Não sei ☐

27. Com que medidas? Por favor indique as 3 mais importantes

1) _____

2) _____

3) _____

28. Acha que um plano de gestão melhoraria a gestão do polvo da região?
Não ☐ Sim ☐ Talvez ☐ Não sei ☐

29. Gostaria de estar envolvido no plano de gestão? Não ☐ Sim ☐ Talvez ☐ Não sei ☐

30. Se não, porquê? Se sim, como?_____

31. Acha que o plano deveria ser exclusivamente feito pelos pescadores?
Não ☐ Sim ☐ Talvez ☐ Não sei ☐

32. Quais são as principais razões para a falha de uma determinada medida de gestão? Escolha todas as que se aplicam:

Baixo/falta de respeito pela legislação por parte dos pescadores ☐
Medida pouco realista ☐
A medida era má desde o início ☐
Falta de fiscalização ☐
Outro_____

_____
_____
_____
_____

Secção D: Informação sobre si

33. Qual é a sua idade? _____ 33.1 Há quantos anos é pescador? _____

34. sua esposa trabalha? Não ☐ Sim ☐

*34.1*Se sim - Trabalho dela é relacionado com a atividade pesqueira? Não ☐ Sim ☐

35. O seu pai era pescador? Não ☐ Sim ☐

*35.1*Há quantas gerações dependem da pesca _____

36. Os seus filhos trabalham na pesca? Não ☐ Sim ☐

*36.1*Gostava que trabalhassem? Não ☐ Sim ☐ Talvez ☐ Não sei ☐

*36.2*Porquê ? _____

37. Tem alguma outra fonte de rendimento para além da pesca? Sim ☐ Não ☐

*37.1*Se sim, de que atividade? _____

38. Qual é o seu nível de escolaridade?

Não concluiu primária (menos que 4ª classe / menos de 4 anos de escolaridade) ..... ☐
Primaria concluída (4ª classe / 4 anos de escolaridade) ..... ☐
1a ciclo (6º ano / 6 anos de escolaridade)..... ☐
3o ciclo (9º ano / 9 anos de escolaridade)..... ☐
Secundária (12º ano / 12 anos de escolaridade) ..... ☐
Educação universitária / superior ..... ☐

39. Onde vive? _____

_____
_____
_____
_____

Muito obrigado(a) pela sua participação!